

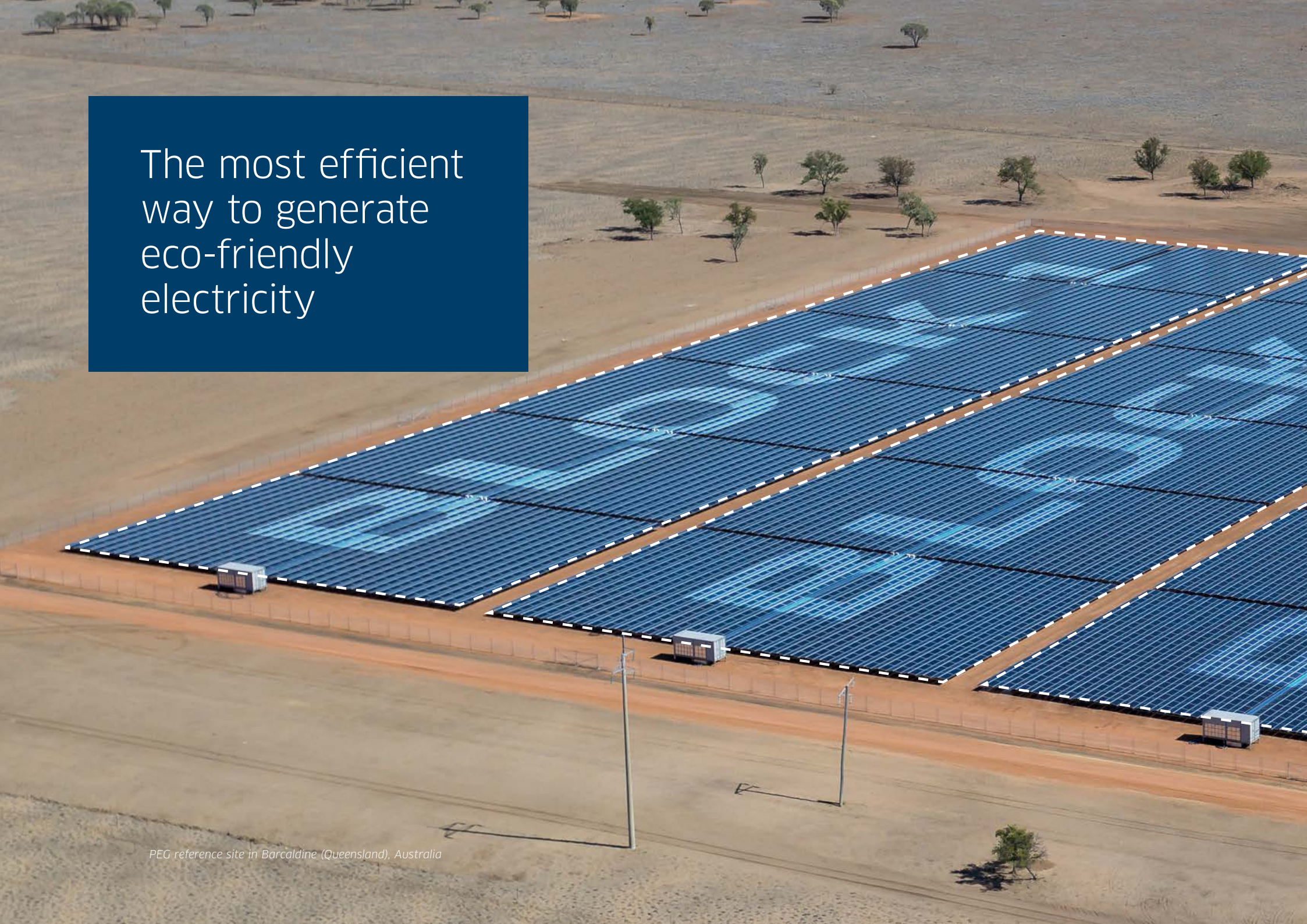


PEG[®] PV Plant

The Revolution in
Utility-scale PV Power

Reaching the lowest cost of electricity with a worldwide patented PV plant technology

The most efficient
way to generate
eco-friendly
electricity



PEG reference site in Barcaldine (Queensland), Australia



BELECTRIC's PEG power blocks energize your power grid with clean and affordable electricity

The Revolution of Renewable Energies

It's not only a historical milestone - in fact it was this great step in human electrification when Thomas Alva Edison invented the electric light bulb and afterwards the power utilities - the basis of today's power grids. Now, over 130 years later we are in for the next revolution in electricity: The Transition to Renewable Energy.

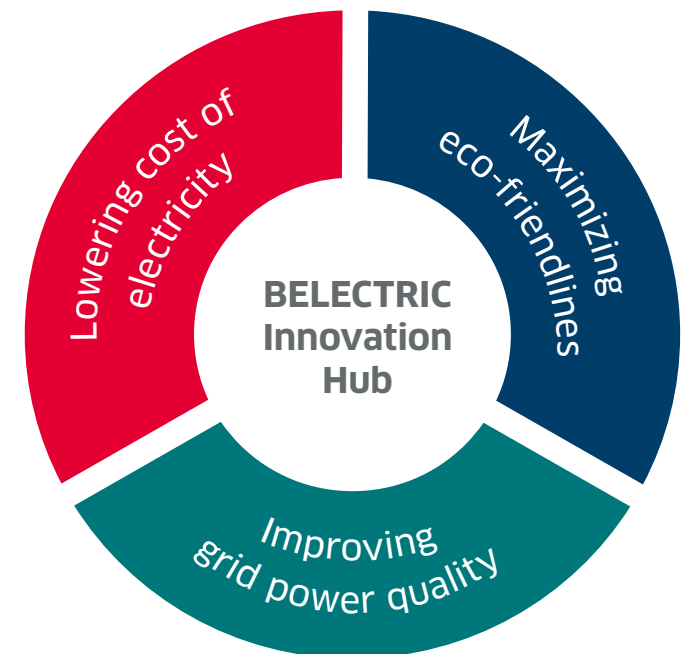
In the last decades our behavior in power consumption has changed. The demand for electricity in this "digital age" is highly individual. The growth of electric mobility claims more grid capacities. We should balance with this needs to generate that power in an eco-friendly manner.

Renewables are a global revolution.

Back in 2000 the only renewable energy source that was practically generating electricity was hydro. Over the last decade renewable technologies have been enhanced - acting much more efficient.

Today, solar power generation through photovoltaics is the most valuable way for mankind to generate eco-friendly electricity.

Critical arguments based on the volatile power generation have been refuted with the power of decentralized battery energy storage systems and smart grid technologies.



Solar PV Industry Challenges

Levelized cost of electricity (LCOE)* is the main indicator to drive investment decisions. The key drivers are:

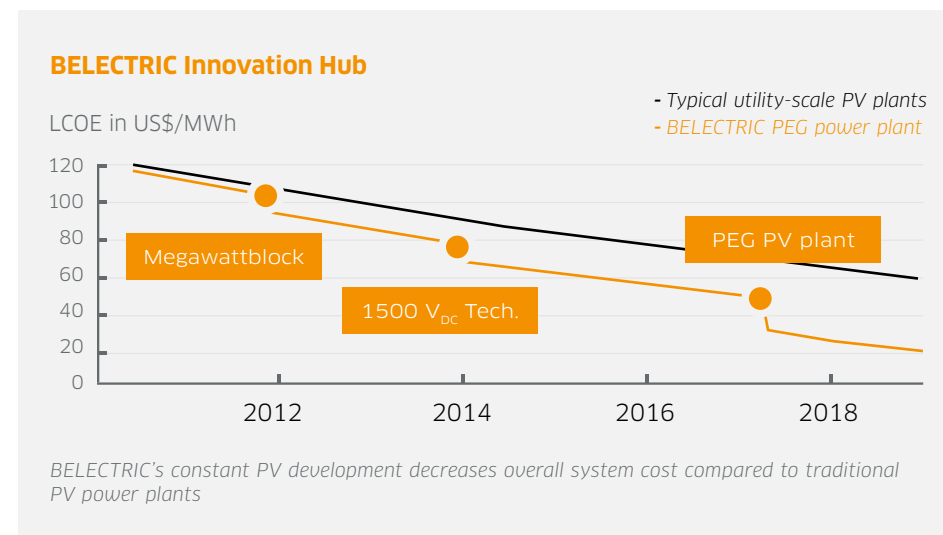
- **Investment cost for system installation (CAPEX)**
- **Operation and maintenance cost (OPEX)**
- **Average annual electricity yield (kWh per year)**

The market for solar PV (photovoltaics) is mainly driven by the continuous technology development which is improving the performance of the system and at the same time decreasing the cost. The PV cost of electricity has been decreasing over the last years. Higher system efficiencies, lower material usage and more innovative manufacturing processes are going to set a scene for the future market developments.

Recent reports show that LCOE for utility-scale PV power is cost-competitive with all of our general sources for electricity generation.

PV modules hold one of the main cost of a PV power plant. But over 60 % of system costs are generated by substructure, wiring, inverters and engineering and construction efforts. With its in-house capabilities BELECTRIC has started to think differently and rework the traditional EPC process. As one of the leading PV

technology companies BELECTRIC developed something real new: The PEG PV plant. With the new system design the whole approach to build up solar PV power plants has changed. BELECTRIC PEG is operating at a price point, which is up to a third lower than the rest of the PV industry. PEG is actually the most cost-efficient way to produce electricity.




* Levelized cost of electricity (LCOE) is an industry primary metric for comparing overall electricity costs produced by a power generator



“I’d put my money
on the sun and
solar energy.”

Thomas Edison

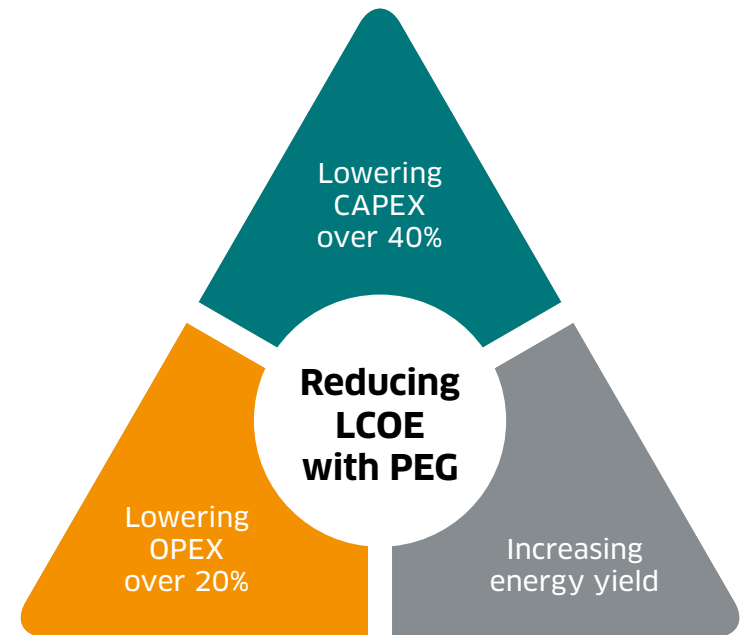


PEG[®] saving
CAPEX
over 40%
compared
to common
PV plants

The PEG Effect: Save CAPEX and OPEX

For many years solar photovoltaics has been defined by its typical **Engineering-Procurement-Construction (EPC)** process. Today, BELECTRIC is challenging this old-fashioned principle with **Engineering-Procurement-Installation (EPI)** - a new PV power realization process focused on quick and resource-saving installation.

PEG system was formed with a simple goal in mind: create a power unit to deliver electricity at lowest possible levelized costs of energy (LCOE), with best in class technologies, long-term reliability and large volume scalability. The PEG unit significantly reduces both substructure supply and delivery, as well as installation costs.



PEG CAPEX savings:

-90%     
machine costs     

-50%     
logistic costs     

-70%     
labor costs     



Lower CAPEX

With PEG's simplified system design there are no reasons for months of planning, a time consuming consulting and expensive construction tasks.

PEG works nearly without ground soiling foundations. No heavy construction machines are needed. Components are partly shipped pre-configured in container-based units.

Lower OPEX

BELECTRIC's decades-long O&M experience has been run into the PEG development. Due to new working ergonomics and an above ground installed DC cabling maintenance costs can be reduced by a quarter.



A rod, which changes everything.

The new system design is based on a PV module mesh, which is borne by many rods. The whole logistic and realization process changes.



PEG[®] vs. common PV Plants

Comparison of:	Traditional Solar Power Plant	PEG Power Plant
Area utilization	Medium, cause system-related free space between straight PV module lines	PV module mesh with highest area utilization
Raw materials	High amount of steel, wood and concrete	No concrete, no wood; saving up to 65% steel
Project process	EPC: Engineering, Procurement, Construction over several months	EPI: Quick Engineering, Procurement and Installation over a few weeks
Engineering	Predominant individual process	3D scan-assisted planning with standardized PEG clusters; customer choice: Manufacturer of PV modules and inverter system
Procurement and logistics	Individual planning and components » complex transportation planning, customer duties and logistic efforts	Easy material flow, transport planning and logistic process by container-based units
Installation	Heavy machinery and many workmen with different skills with driving licenses needed; Construction works partly overhead (substructure, PV mounting)	Simplified process with small teams; nailing and mounting with hand tools; Besides AC/DC configuration no special skills needed; no heavy machines; no overhead working; no cable trenching
Operation & Maintenance	Overhead working, difficult tests with underground cabling	All component are installed over-ground with working height around one meter
Energy yield	Peak power generation at noon time	Balanced power generation with better energy yield at sunrise and sunset due to east/west exposition



No complex substructure



No heavy machines



It's not EPC, it is EPI

(Engineering-Planning-Installation)

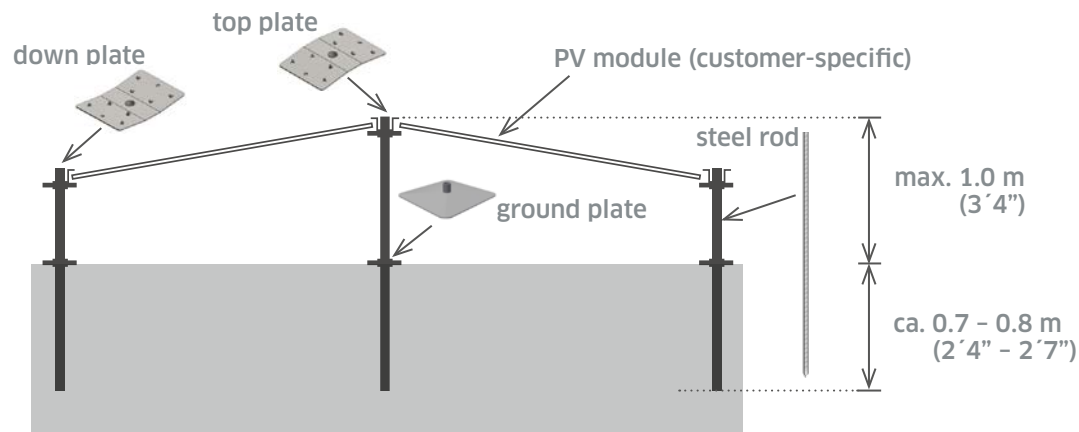
The PEG power plant will be installed rather than constructed. It is based on an innovative system design, which follows the ground surface - the PEG mesh. The ground-nailed substructure clamps the PV panels at about one meter elevation over-ground. The specially engineered construction design with its flat 'zigzag' pattern is very durable against environmental

impacts. Furthermore at high wind loads the patented construction produces a down-lift, which increases the static characteristics.

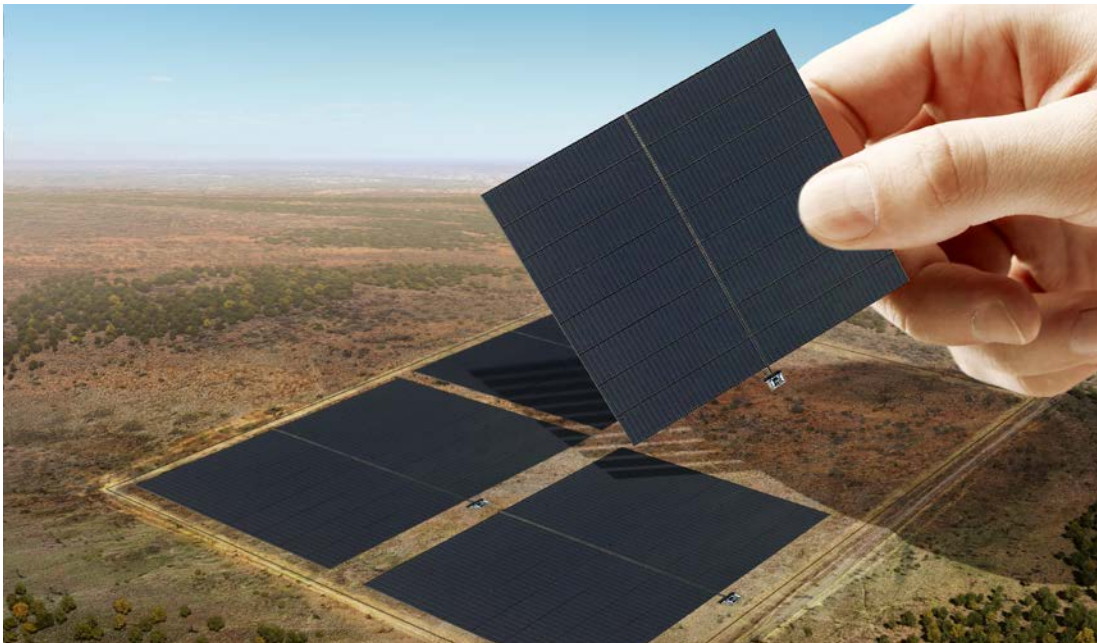
The PEG System is a revolution in the field of substructures for PV power plants with framed modules. It is a unique solution and especially designed for **east/west exposition**.

The PEG system significantly reduces both substructure supply and delivery as well as installation costs. Due to the lightweight construction no foundation is needed. Less material and a simple design lead to reduced labor costs and the phase between planning and commissioning is reduced significantly.

The PEG substructure is the lightest, most efficient and innovative system on the market. Substructures of our competitors are much heavier and more expensive. Most of them need concrete foundations and heavy machines. With PEG, the steel rods of the PEG substructure can also be installed with only a hammer drill.



Outstanding innovations behind PEG[®]



PEG reference site in Goondiwindi, Australia





1.70 MWp*
per **one** 40 ft. container
for the substructure



1.25 kWp*
per man-hour



1.7 MWp*
per hectare
(0.7 MWp per acre)



* Figures refer to 380W modules and may differ regionally.

PEG[®] Engineering

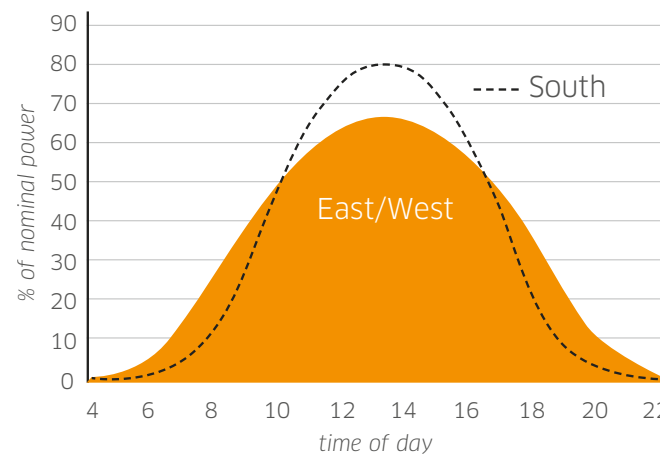
With PEG the engineering process has been enormously simplified. Cause substructure is based on a rod-mounted PV mesh, it's easy to plan a PV plant on a selected client surface. The ground leveling and the alignment of the PEG blocks are assisted by 3D scan and CAD engineering.

Clustering PEG power blocks

The whole engineering process has been simplified by a clear standardization with PEG system blocks. Related to PV panel type and the selected level of DC system voltage (1000 to 1,500 V_{DC}) PEG engineering process works with pre-defined power blocks.

In contrast to conventional PV module lines, the PEG mesh utilizes a greater power-generating photovoltaic area. The flat - typical east-west oriented - PV generator creates a smoother daily averaged electricity yield. Grid-connection points are less stressed and feed-in power peaks are more reduced.

Consistent energy generation across the day:



PEG engineering benefits:

- Fully scalable system design
- High location variety: Like a millipede, numerous mounting poles will be adapted to the ground and establish a new freedom of site selection
- Suitable for many PV module types
- Freely adaptable for 1,000-1,500 V_{DC}
- Most effective land utilization for utility-scale photovoltaics
- Low visual and ecological impact
 - ▶ simplified approval procedures



Self stabilizing



Low visual impact



Wind-proofed *

* Designed for 2,400 Pa module pressure load;
Max. wind speed is 135 mph (60.3 m/s)

Most effective land utilization.

Low visual impact.

Full scalable from 10 kWp to MWs.

The revolution in utility-scale PV power:

Best-in-class area utilization of 1.7 MWp* per hectare

(0.7 MWp per acre)



* Figures refer to 380W modules and may differ regionally.

Reduced raw materials.
No concrete foundations.
Unit-based packaging.
No construction vehicles.



-50%

logistic
costs



PEG[®] Procurement

Never again dealing with heavy loads and on-site problems with impassable terrain; never again dealing with complex customs clearance. Besides its simplified engineering and installation workflow PEG system has one more ace up in sleeve: The consumption of raw materials and production resources is enormously lower compared to traditional solar PV projects.

All that even goes so far that you can install the whole DC-related PEG power plant with a small team equipped with some hand tools. Just for transportation purpose on-site BELECTRIC is using a compact track loader.

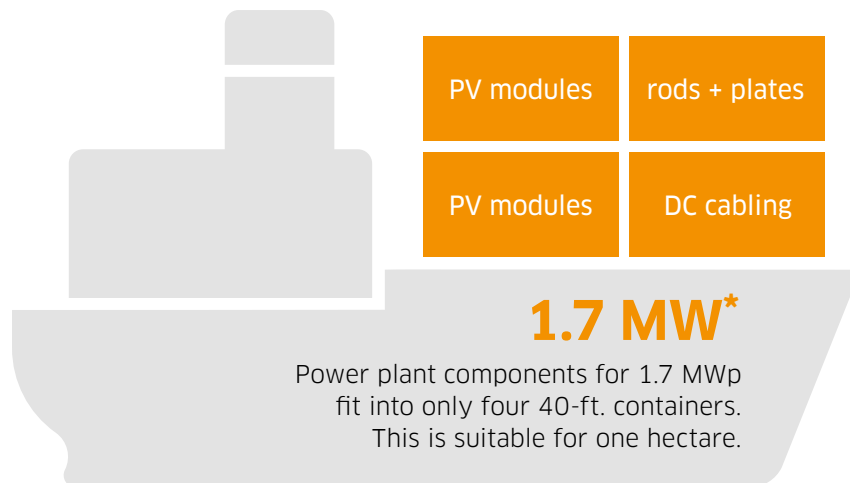
This elementary simplification opens up huge savings for PEG material procurement and project logistics. In short, four maritime containers are sufficient to transport a PEG power plant with one megawatt DC capacity.

PEG's revolutionary system design enables transportation to far reaches all over the world. Thus not only on-grid capacities but also off-grid systems can produce eco-friendly, decentralized electricity.



PEG procurement benefits:

- Minimal material and transport cost
- Significantly reduced steel consumption
- Eliminates need for concrete foundations



* Figures refer to 380W modules and may differ regionally.



PEG[®] Installation

The PEG power plant installation is based on a quick nailing process. Only four workmen are necessary to start-up a PEG power plant installation. Like an ink-based office printer is completing a print out, the PEG power plant will be installed line-by-line. In contrast to traditional PV power plant suppliers the working process does not depend on heavy working machines or vehicles. Most works can be run at waist level to ensure an ergonomic and HSE optimized working environment.

Despite the high-level of standardization the PEG system design is compatible to many PV panel manufacturers. For best individualism the customer can choose his favored panel type.



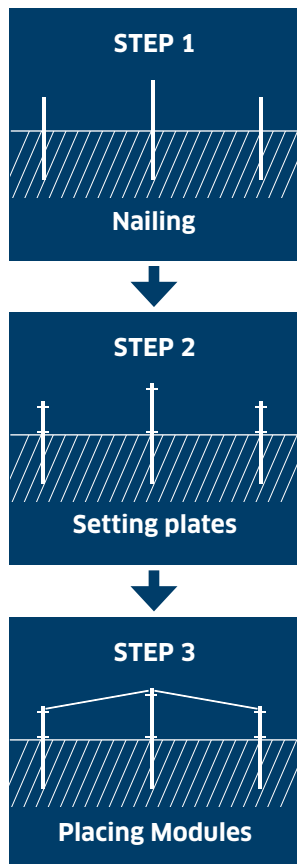
Easy and fast installation with PEG:

- Installation speed: 0.8 man-hour per KWp
- Simple installation process:
 - no need for special construction requirements and heavy machinery
 - no concrete foundations
 - no cable trenches
- Reduced risks and cost in terms of HSE
- All components installed over-ground (no underground works necessary)
- Ergonomic working height: 0.6 m to 1.2 m (2 to 4 feet)
- PEG will be installed line by line with an easy nailing placement process
- Simple and residue-free dismantling after project life, in case of different land use designation

* Figures refer to 380W modules and may differ regionally.

No heavy machines.
No concrete foundations.
Simpler HSE procedures
on project site.

3 Steps to PEG:



Operation and Maintenance

BELECTRIC O&M services help to support continuous PV plant operation, giving higher energy yield and therefore high return on investment across life-cycle. From daily operation, routine and scheduled maintenance, to outage services our service team meets the demands of customers' individual operational and maintenance models comprising as risk sharing mechanisms.

- **Remote monitoring and diagnostics**
- **Maintenance**
- **Spare parts and obsolescence management**
- **Warranty extensions**
- **Response time guarantees**
- **Availability guarantees**

While developing the new PEG system our engineers considering BELECTRIC's know-how and long-time experience in the operation and maintenance of large-scale PV power plants. In result PEG's low substructure with overground DC cabling allows a simplified site inspection.

Besides, BELECTRIC introduces a new, smart O&M work-flow, especially a robot-assisted PV module cleaning process, an optional PEG mowing robot and an O&M service bench to access single PV modules on-site.

The PID reduction technology and long-term guarantees of all PEG integrated components safe a reliable operation.



Quick and easy site inspections:

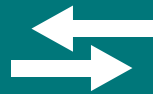
- *Low substructure allows easy site inspections*
- *No parts installed under ground*
- *Quick and easy full-string check ups*
- *PV module servicing with PEG working bench*

PV site care

- *Automated PV module cleaning robot*
- *Robot-assisted turf mowing (in normal case not necessary with PEG)*



O&M solutions
especially for PEG.
Easy to use and efficient.



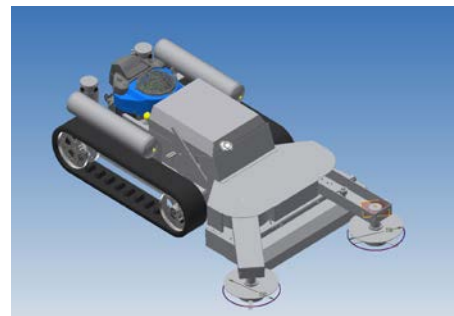
Easy module
replacement



For module replacement TÜV certified
MULTIBOARD is the perfect solution
to walk over the module rows.



Autonomous
mowing robot



The **MOWING ROBOT** is specially
designed for the PEG system. The
robot drives by remote and auto-
nomously through the panel rows.



Fast + effective
cleaning

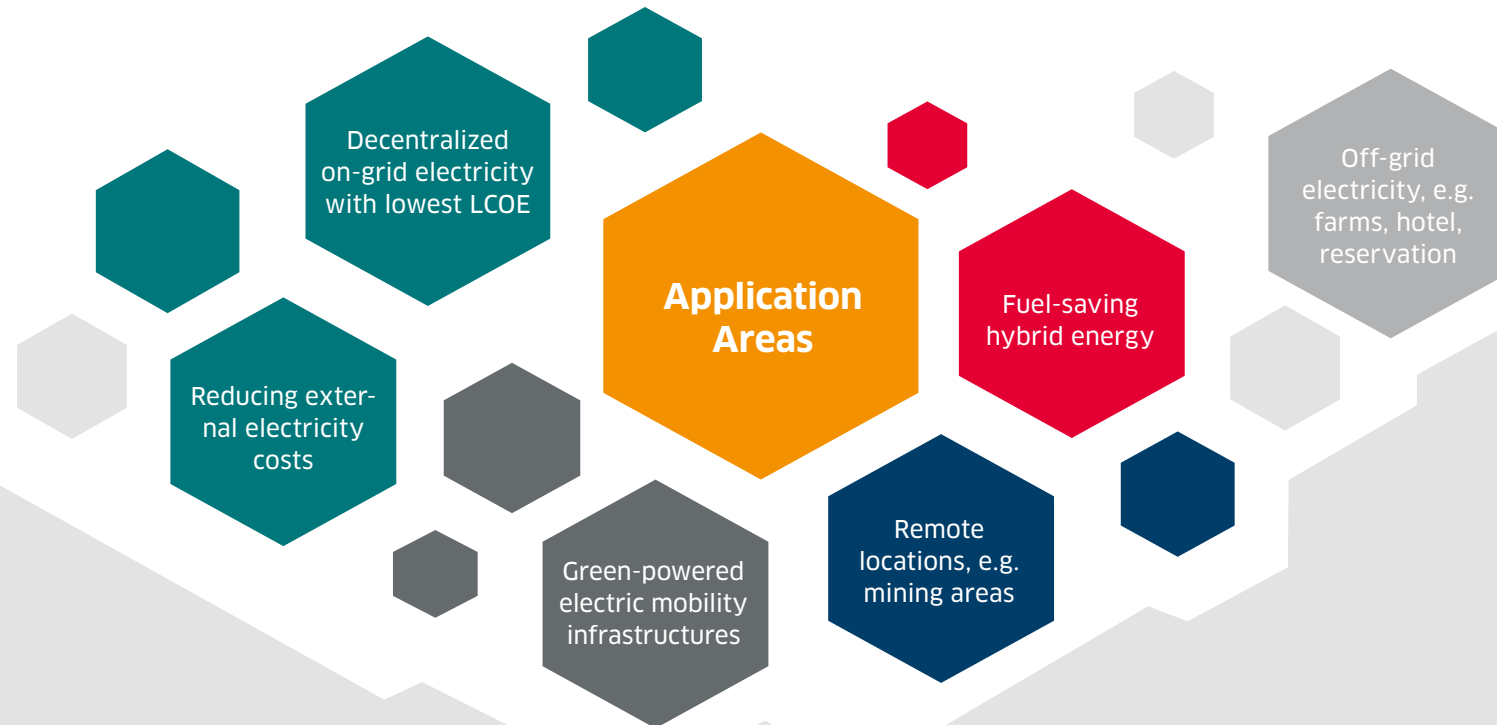


The **GAL-IN SOLUTION** is specifically
designed for the PEG design (V-shape)
and works very efficient.

PEG[®] placement options

PEG PV plants are feasible in nearly every environment where affordable electricity is needed. Our engineers had tuned all components to operate under desert-proofed conditions as well as under Nordic climates. With it's easy to transport units and weights PEG systems can be delivered to very remote locations. The high level of standardization make it possible to place a PEG power block to a variety of ground surfaces. This freedom in the choice of location and PEG's optional battery and hybrid control extensions are enabling new business models for our customers.

How can PEG optimize your business?





Free scalable and
application-oriented
PEG placements



PEG[®] applicable: Battery Storage and Hybrid power

Besides its high solar PV expertise BELECTRIC develops industrial systems for battery storage and hybrid solutions. With these new technologies climate-friendly solar power will be combined with the benefits of fuel-based energy sources.

Lithium-Ion based battery storage and hybrid control units can be integrated into a PEG PV plant. The battery storage reacts on load and voltage variations in milliseconds. BELECTRIC's Energy Buffer Unit (abbr. EBU) enables ancillary grid stabilization services like black start, island operation and virtual inertia. It can provide grid stabilization through primary frequency response, enhanced frequency response, RoCoF

response, load shifting, peak shaving. As BELECTRIC PEG, the LION EBU is designed for maximal scalability and flexibility. It can be adapted for today's needs at local or national power grids, guaranteeing a stable grid, and even allowing more renewable energy in the near future.



Battery and hybrid benefits:

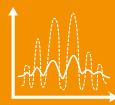
- *Highly standardized hybrid and battery power units compatible with PEG PV plant*
- *Improve power quality at regional grid*
- *Enables ancillary smart grid services*
- *Independent electricity 24/7 with maximized use of fuel-less solar PV*
- *Improve island and off-grid, micro-grid infrastructures*



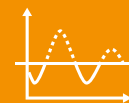
Hybrid



Island Power



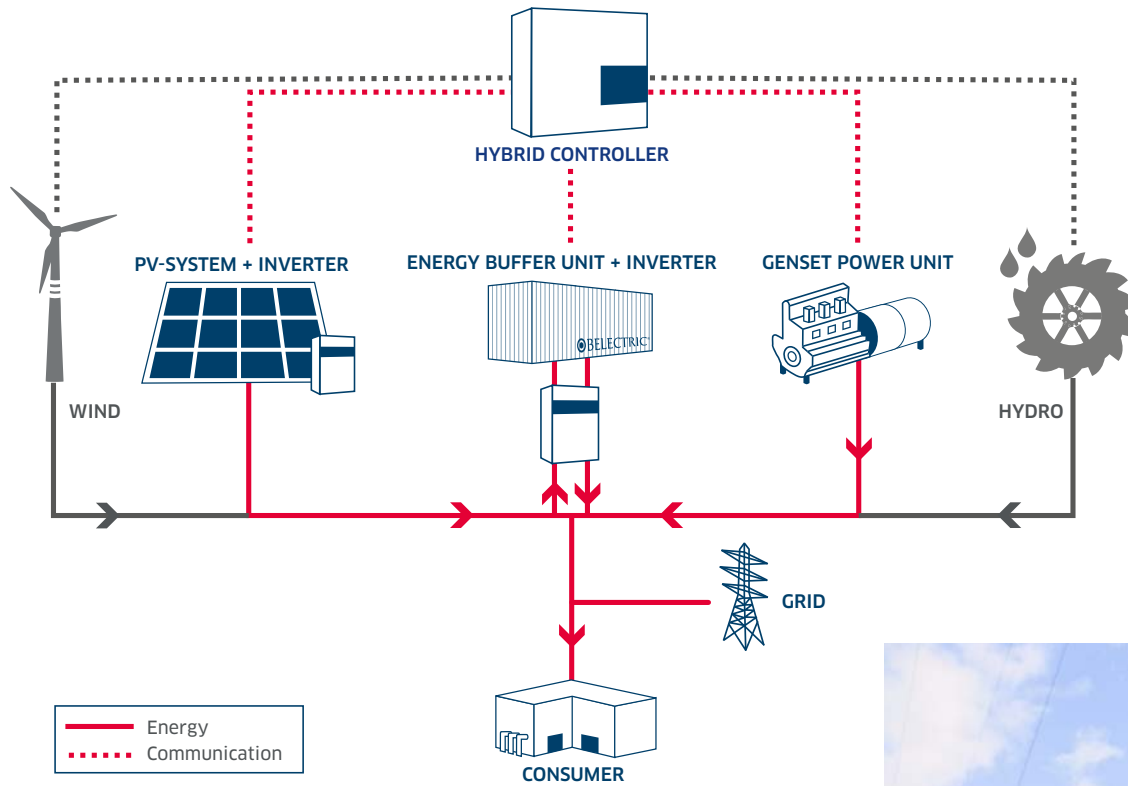
Fast response
Frequency Control



Peak Shaving



EV Charge



Optimize grid
quality and reduce
fuel consumption



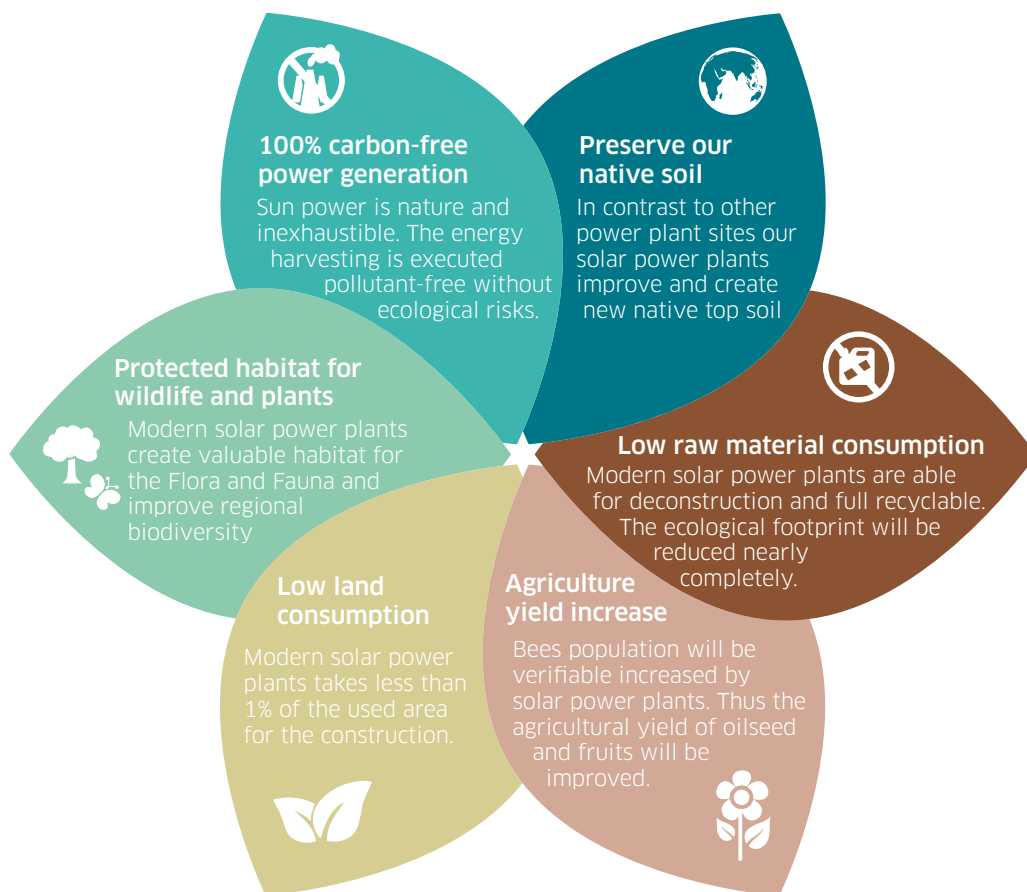
Low ecological footprint
in manufacturing, logistics
and installation.

Low land consumption.

Completely dismantlable
PV plant.

Solar energy
is a gift from
nature





Wildlife under threat

European farmland has changed greatly over the last decades. The old patchwork of mixed-use farms, with small fields surrounded by hedgerows and wild margins, provided abundant food and shelter for a wealth of wildlife. Today's farmland is dominated by industrial-scale mono-culture, often blanketing large expanses with crops such as cereals that provide little succor to wildlife – even to the pollinating insects on which other crops rely.

Solar farms put life back into countryside

Solar farms inject clean renewable energy directly into the power grid. We feel they should be enthusiastically embraced as not only a core part of the long-term solution to securing our national energy supply and meeting international climate change targets, but also as a boon for biodiversity. A little known fact about solar farms is that less than 5% of the land underneath has anything physical attached to it, meaning that more than 95% can be used throughout its lifetime to support wildlife.









Ecological benefits for PEG vs. traditional solar PV:







- Ecological footprint is much lower due to less raw materials and logistic efforts
- Protection of rare top soil cause no concrete works necessary and all DC cabling is fixed overground



PV substructure
conforms to
UL Std. 2703

Approved modules

Manufacturer / Module series	Manufacturer approval	UL certification
	●	○
	●	○
	●	○
	●	●
	●	●
	●	●

Manufacturer / Module series	Manufacturer approval	UL certification
	●	○
	●	○
	●	○
	●	○
	●	○
	●	○

Detailed informations about the approved module types can be found in the approval list.



Specifications and approvals

Technical data	
Orientation PV array	Patented 8° East-West, fixed tilt, aerodynamic proofed (patent-registered design)
BOM (Bill of material)	1.10 rods and 2.15 clips per module
Large volume scalability	Any power plant capacity from at 10 kWp is possible
Durability	Hot deep galvanized steel rods and pre-galvanized steel plates. PV modules and clips based on corrosion-free aluminum and glass. All DC cabling components are weatherproof and UV resistant.
Wind loads	Designed for 2,400Pa module pressure load; compliance with wind codes is TBD by local engineering company per wind region
Valid air temperature	Up to 50°C, 122°F (up to 55°C, 131°F with Hot Climate Option)
Certifications	Clamping approval from module manufacturers. Wind load certificate by local engineering firm in accordance with local wind codes. The PEG substructure is UL certified.
Warranties	Warranty time has to be defined per project based on the site and soil conditions. Functional warranty, excluding cosmetic issues like rust. Standard warranty and geotechnical tests guidance documents available upon request.

Requirements	
Land soil condition	Cohesive (e.g. sandy-clay, clayey silt) and non- cohesive soil (e.g. sand or sand-gravel).
Upper soil layer	No rocks or underground infrastructure up to 1m (3'4") below ground; rammed depth up to 0.8m (2'7")
Site slopes	The PEG system can be installed on slopes of up to 4.5 deg. In case the site slope is up to 2 deg, the rods should be vertical to the horizontal plane. In case the slope is higher than 2 deg., the rods should be vertical to ground slope.





PEG® – Harvesting the Power of the Sun

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BELECTRIC Solar & Battery GmbH is one of the most successful enterprises in the development and construction of utility-scale solar PV power plants and battery storage systems. The company was established in 2001 and has been expanded to an international group with activities on all continents since then.

BELECTRIC has constructed 300 solar PV power plants with around 2 GWp PV capacity. In addition, the company realized battery energy storage systems and hybrid power solutions, which combines different technologies to autarkic systems. As one of the largest O&M providers globally, BELECTRIC's full-integrated services provide continuous operation.